BUS GoCircular

Shaping a Circular Sustainable Future

Module 6

Energy and the Circular Economy

Circular Economy in the Construction Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

Summery

The trainer will explore multiple facets of energy in construction gaining a general overview of the impact of energy in construction and the opportunities that present themselves when correctly implementing energy saving and collection methods. This will then be related to the many opportunities associated with energy and Multi-functional Green Roofs Facades and Interiors Elements.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

Objectives/Learning Outcomes

- 8 – Select sources with less impact to apply to operations in buildings
- 9 – Enact measures that reduce and optimise energy use through solutions on roofs and facades whilst taking into account building purpose and climate
- 10 – Generate energy or heat/cold from renewable sources in design of multifunctional green roofs, façades, and interior elements
- 24 – Enact measures to use and store energy more efficiently in buildings
- 56 – Install energy efficiency measures on roofs, façades, and interior elements

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Objectives/Learning Outcomes

- 63 – Install renewable energy technologies in buildings to generate power or heat/cold
- 67 - Install measures to use and store energy more efficiently in buildings

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Content

- Energy in Construction
  - Energy and the Circular Economy
- Energy and Sustainable Use in Construction
  - Renewable energy sources
- Application for Multi-functional Green Roofs Facades and Interior Elements

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Energy in construction

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Energy in Construction

In very general terms, energy is a capacity to do work that can take a number of different forms, such as; thermal (heat), radiant (light), motion (kinetic), stored (potential), secondary (e.g. electricity), chemical, mechanical, and so on.

The term 'energy consumption' refers to the amount of energy that is used by a process, system, product, community and so on.

Source: https://www.designingbuildings.co.uk/wiki/Energy_consumption_in_the_construction_industry

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Energy in Construction

Today, roughly 75% of the EU building stock is energy inefficient. This means that a large part of the energy used goes to waste. Such energy loss can be minimised by improving existing buildings and striving for smart solutions and energy efficient materials when constructing new houses.

Source: https://commission.europa.eu/news/focus-energy-efficiency-buildings-2020-02-17_en

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Energy in Construction

Some of the most important elements in EU directives include

- reinforced long-term renovation strategies for EU countries
- nearly zero-energy buildings
- energy performance certificates
- Smart Readiness Indicators to assess a building's ability to adapt to advanced technologies in terms of its performance capacity and energy flexibility.
- consideration for health and well-being (air pollution), e-mobility (e-charging points) and smart technology (smart meters, self-regulation equipment) in new buildings

Source: https://commission.europa.eu/news/focus-energy-efficiency-buildings-2020-02-17_en

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Energy in Construction

In a domestic context, energy consumption is often attributed to:

- Heating.
- Hot water.
- Cooling and refrigeration.
- Lighting.
- Ventilation
- Washing and drying.
- Cooking.
- Other electric loads.

Source: https://www.thisoldhouse.com/lighting

Source: https://www.designingbuildings.co.uk/wiki/Energy_consumption_in_the_construction_industry

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Whole Life Energy

The energy consumed by a building throughout its whole life comprises:

- Initial embodied energy. The energy consumed to create the building, including; extraction, processing and manufacture, transportation and assembly.
- Recurring embodied energy. That is the energy consumed in refurbishing and maintaining the building during its life.
- Operational energy. The energy consumed in heating, cooling, lighting and powering appliances in the building.
- Demolition energy: The energy consumed in the disposal of the building.

Source: https://www.designingbuildings.co.uk/wiki/Energy_consumption_in_the_construction_industry

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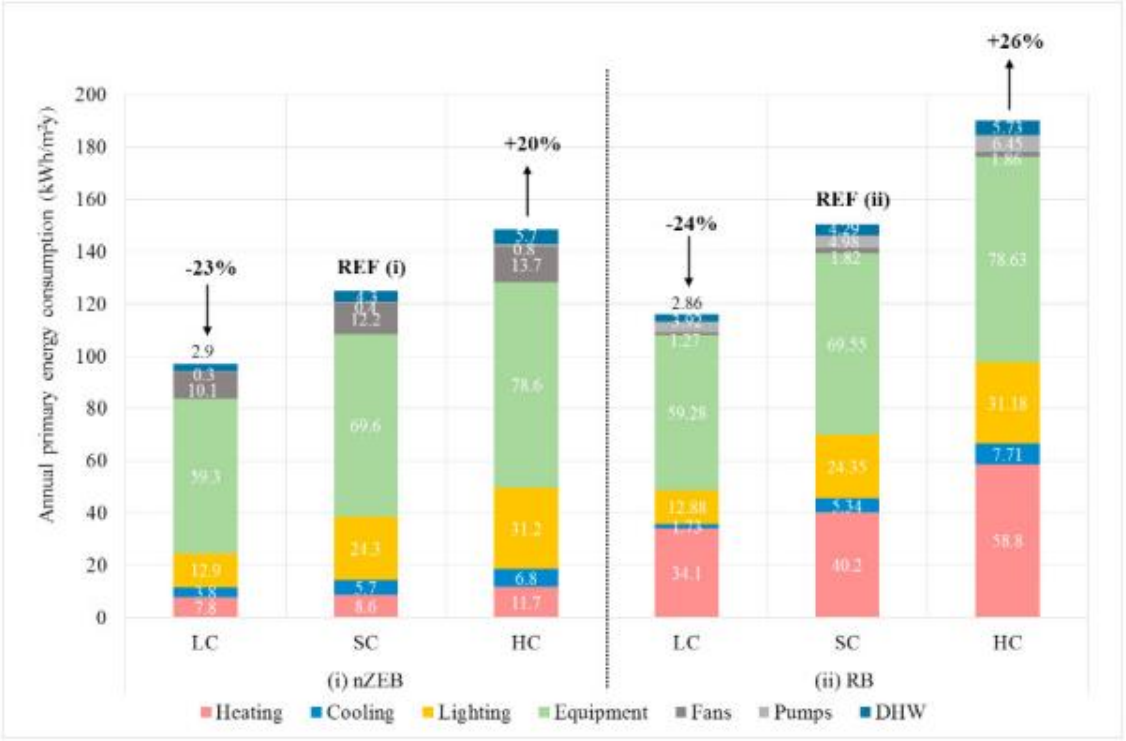
Occupational Energy Use

Occupant behaviour is known to be one of the key sources of uncertainty in the prediction of building energy use.



Source: Annual primary energy consumption of the analysed scenarios

Source: https://www.sciencedirect.com/science/article/pii/S1876610217355376

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Occupational Energy Use

‘Raising User Awareness’ is the most important aspect when considering occupational energy use in a building. This can span from nZEB or other energy efficient building to building that perform poorly as energy efficiency measures can be carried out by any occupant once there is a general understanding of how this can be done.

Source: https://www.sciencedirect.com/science/article/pii/S1876610217355376

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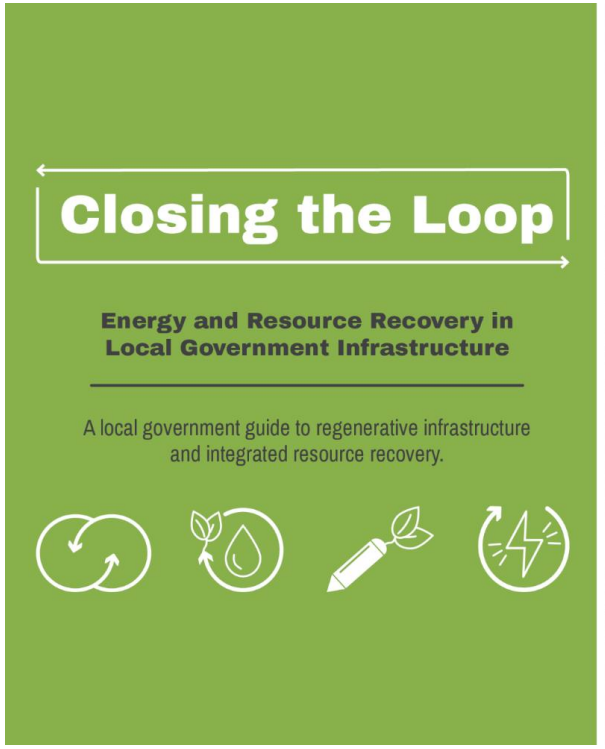
Energy and the Circular Economy - Closing the Loop

It is vital that we not only reduce our consumption of energy but that we actually keep energy in use once it has been created. Closing the loop is a term used when describing the act of keeping a material in use for as long as possible, in this case it means that once water enters a building or site it is reused as much as possible before it must be sent off site or allowed to be lost.



Source and Further Reading: https://www.communityenergy.ca/projects/closing-the-loop/

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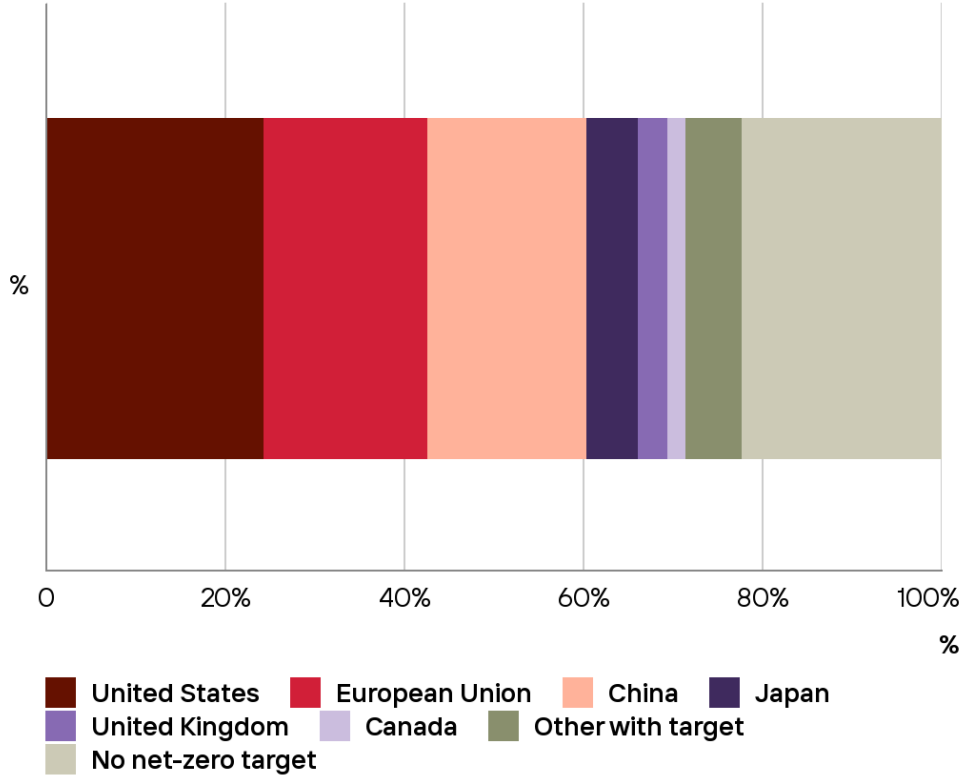
3 Ways the Circular Economy is Vital for the Energy Transition

1. Recycling can conserve critical materials
2. Using low-carbon, circular materials
3. Designing circular systems



Source:https://www.weforum.org/agenda/2022/02/3-ways-circular-economy-renewables-energy-transition/

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Energy and Sustainable Use in Construction

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Energy and Sustainable Use in Construction

Renewable energies are natural resources that can be replaced or replenished with usage. When implementing energy-based sustainable construction techniques, companies should strive to use renewable resources. The construction industry has a history of nonrenewable energy usage and has seen little change in consumption in the last 20 years. As there is a finite amount of nonrenewable energy, this results in a huge strain on resources.

Source: https://www.chas.co.uk/blog/sustainable-construction-techniques/

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Reduce Heating, Cooling, And Lighting Loads Through Climate-Responsive Design And Conservation Practices

- Use passive solar design; orient, size, and specify windows to balance daylighting versus heat loss; and locate landscape elements with solar geometry and building load requirements in mind.
- Use high-performance building envelopes; select walls, roofs, and other assemblies based on long-term insulation, air barrier performance, and durability requirements.
- Consider an integrated landscape design that provides deciduous trees for summer shading, appropriate planting for windbreaks, and attractive outdoor spaces so that occupants wish to be outdoors—thereby reducing the occupant-driven additional heat loads to the building.

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

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Specify Efficient HVAC (Heating, ventilation, and air conditioning) And Lighting Systems

- Use energy efficient HVAC equipment and systems.
- Incorporate strategies to reduce excessive air changes and use energy recovery systems for makeup air.
- Introduce combustion air strategically into the building enclosure for mechanical equipment by using sealed combustion or ducted systems rather than simple louvered wall openings.
- Use lighting systems that consume less than 1 watt/square foot for ambient lighting.
- Use Energy Star® approved and/or FEMP-designated energy efficient products or products that meet or exceed Department of Energy standards.

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

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Specify Efficient HVAC (Heating, ventilation, and air conditioning) And Lighting Systems

- Evaluate energy recovery systems that preheat or pre-cool incoming ventilation air in commercial and institutional buildings.
- Investigate the use of integrated generation and delivery systems, such as co-generation, fuel cells, and off-peak thermal storage. See also WBDG Distributed Energy Resources (DER) and Microturbines.

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

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Employ Renewable Or High-Efficiency Energy Sources

- Renewable energy sources include solar water heating, photovoltaic (PV), wind, biomass, and geothermal. Use of renewable energy can increase energy security and reduce dependence on imported fuels, while reducing or eliminating greenhouse gas emissions associated with energy use. Consider solar thermal for domestic hot water and heating purposes.
- Evaluate the use of building scale to take advantage of on-site renewable energy technologies such as solar water heating, and geothermal heat pumps.
- Consider the use of larger scale, on-site renewable energy technologies such as photovoltaics, solar thermal, and wind turbines.
- Evaluate purchasing electricity generated from renewable sources or low polluting sources such as natural gas.

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

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Optimize Building Performance And System Control Strategies

- Employ energy modeling programs early in the design process.
- Evaluate the use of modular components such as boilers or chillers to optimize part-load efficiency and maintenance requirements.
- Use sensors to control loads based on occupancy, schedule and/or the availability of natural resources such as daylight or natural ventilation during building operations.
- Provide HVAC night and weekend setbacks where applicable to reduce heating and cooling loads when the building is unoccupied.
- Evaluate the use of Smart Controls that merge building automation systems with information technology (IT) infrastructures.
- Employ centralized remote meter reading and management to provide accurate analysis of energy use and monitor power quality.

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

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Optimize Building Performance And System Control Strategies

- Use metering to confirm building energy and environmental performance through the life of the project.
- Use a comprehensive, building commissioning plan throughout the life of the project.
- Employ an interactive energy management tool that allows you to track and assess energy and water consumption like the Energy Star® Portfolio Manager.
- Provide electronic interactive graphic dashboards in prominent locations to educate occupants of their building's energy and water consumption and highlight sustainable building features.
- See also WBDG Facility Performance Evaluation.

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

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Deep Energy Retrofits

A deep energy retrofit is a whole-building analysis and construction process that achieves much larger energy cost savings than those of simpler energy retrofits such as upgrading lighting and HVAC equipment. In taking a whole-building approach, deep energy retrofits address many systems at once by combining energy efficient measures such as energy-efficient equipment, air sealing, moisture management, controlled ventilation, insulation, and solar control.

Source: LivingRoofs.org A cable-supported vertical green wall installed on the facade of a building in Switzerland.

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

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Renewable Energy Sources

The main types of renewable energy sources include:

- Solar thermal energy: The conversion of solar radiation to thermal energy in order to heat a working fluid.
- Geothermal energy: The natural heat energy stored in the earth.
- Wind energy: Energy generated by the wind.
- Biomass: A generic term referring to organic materials that can be used as fuels.
- Hydropower: The generation of electricity from flowing water power.

Source: https://theconstructor.org/construction/renewable-energy-sources-powering-construction-sites/561510/

Source: https://www.designingbuildings.co.uk/wiki/Energy_in_the_built_environment

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What is Solar Energy

Currently, solar energy is harnessed using three primary technologies. Which are:

1. *Photovoltaic (PV)* – directly convert light to electricity;
2. *Concentrating solar power (CSP)* – heat is being used from the sun (thermal energy) to drive electric turbines, utility-scale, and
3. *Solar heating and cooling (SHC) systems* – accumulate thermal energy to supply hot water and air heating and/ or conditioning.

Source: https://www.britannica.com/science/solar-energy

Source: https://www.dexma.com/blog-en/how-efficient-are-solar-energy-technologies-for-buildings/

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Advantages of Solar Panels

- Limitless Resource: Solar energy is renewable energy that never ends its supply.
- Low environmental impact: Depending on the scale of the system installed – from distributed rooftop PV arrays to large utilities – solar technologies can produce lower environmental pollution.
- Energy Independence: It makes Buildings energy independent and puts less pressure on natural sources of energy.
- Multipurpose: It can be used in various ways and for multiple applications.
- The ability for Additions: You can expand your PV systems effortlessly as they are modular.
- Portable: Can be transported easily.
- Post-Installation is Zero: Once the infrastructure has been installed no cost will be there after that (except for changing inverters and batteries).

Source: https://www.dexma.com/blog-en/how-efficient-are-solar-energy-technologies-for-buildings/

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Disadvantages of Solar Panels

- The high initial costs of installing panels, the cost an installation of solar panels can be quite expensive when grant opportunities are not available.
- Solar energy storage is expensive. While in sunlight a lot of energy can be created, it is difficult to store this energy for later use and depending on the battery availability this can also be very expensive.
- Solar doesn't work for every roof type. Solar panels can and should only be considered when a roof has access to sunlight for prolonged periods of time meaning ot all buildings can utilise this natural resource.
- Solar panels are dependent on sunlight. This may seem quite obvious, however, it is important to consider whether this is a viable solution for a building owner based on the amount of sunlight the building may get.

Source: https://www.dexma.com/blog-en/how-efficient-are-solar-energy-technologies-for-buildings/

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Photovoltaic (PV)

Solar panels that produce electricity are known as solar photovoltaic (PV) modules. These panels generate electricity when exposed to light. Solar PV is the rooftop solar you see on homes and businesses.

Source: https://energyd.ie/solar-panels-cost-ireland/

*Source:*https://www.seai.ie/grants/home-energy-grants/solar-electricity-grant/about-solar-pv/#:~:text=Solar%20panels%20that%20produce%20electricity,or%20solar%20hot%20water%20collectors.

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Photovoltaic (PV)

A solar electric system (PV) is typically made up of:

- Solar panels on the roof, which generate DC (direct current – like in a battery).
- An ‘Inverter’ which converts this to AC (alternating current – like the electricity in your house socket).
- Sometimes a battery on larger systems to save energy for later use.

*Source:*https://www.seai.ie/grants/home-energy-grants/solar-electricity-grant/about-solar-pv/#:~:text=Solar%20panels%20that%20produce%20electricity,or%20solar%20hot%20water%20collectors.

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Concentrating solar power (CSP)

Concentrating Solar Power (CSP) technologies use mirrors to concentrate (focus) the sun's light energy and convert it into heat to create steam to drive a turbine that generates electrical power.

Source: https://solareis.anl.gov/guide/solar/csp/

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Solar heating and cooling (SHC)

Solar heating & cooling (SHC) technologies collect the thermal energy from the sun and use this heat to provide hot water, space heating, cooling, and pool heating for residential, commercial, and industrial applications. These technologies displace the need to use electricity or natural gas.

Source: https://www.seia.org/research-resources/solar-heating-cooling-case-study-arminta-apartments

Source: https://www.seia.org/initiatives/solar-heating-cooling

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

Solar heating and cooling (SHC)

Solar water heating systems are comprised of three main elements:

- the solar collector
- insulated piping
- a hot water storage tank.

Electronic controls can also be included, as well as a freeze protection system for colder climates. The solar collector gathers the heat from solar radiation and transfers the heat to potable water. This heated water flows out of the collector to a hot water tank, and is used as necessary. Auxiliary heating can remain connected to the hot water tank for back-up if necessary.

Source: https://www.seia.org/initiatives/solar-heating-cooling

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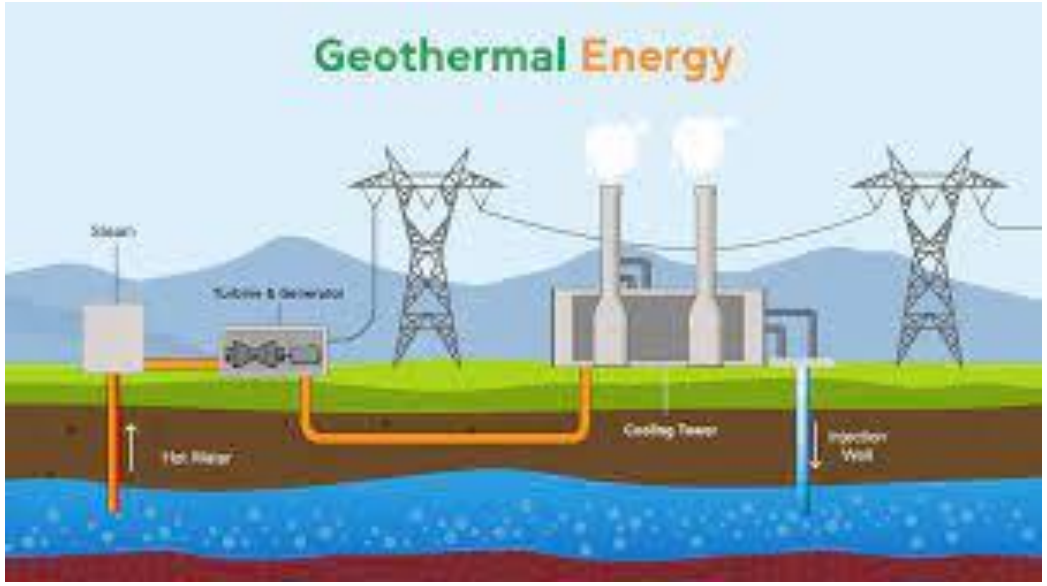
What is Geothermal Energy

Geothermal energy refers to energy stored in the form of heat beneath the surface of the Earth. This energy can be used for heating buildings and businesses, and even for electricity generation in some places.



Source: https://greenesa.com/blog/geothermal-energy-types-uses-advantages

Source: https://www.gsi.ie/en-ie/geoscience-topics/energy/Pages/Geothermal-Energy.aspx

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What is Wind Energy

The sun heats the earth unevenly and this creates thermal air currents. In order to achieve equal temperatures around the earth, these air pockets move about as global wind. The energy that travels in the wind can be captured and converted to provide electricity.

Wind energy provides a clean, sustainable solution to our energy problems. It can be used as an alternative to fossil fuels in generating electricity, without the direct emission of greenhouse gases. And there will always be wind; it is inexhaustible and renewable.

Source: https://archinect.com/forum/thread/79351/building-integrated-wind-turbines

Source: https://www.seai.ie/technologies/wind-energy/

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What is Biomass Energy

Bioenergy is a form of renewable energy generated when we burn biomass fuel. Biomass fuels come from organic material such as

- harvest residues
- purpose-grown crops
- organic waste from our homes, businesses and farms.

*Source:*https://www.seai.ie/technologies/bioenergy/what-is-bioenergy/#:~:text=When%20we%20use%20plants%20and,our%20homes%2C%20businesses%20and%20farms.

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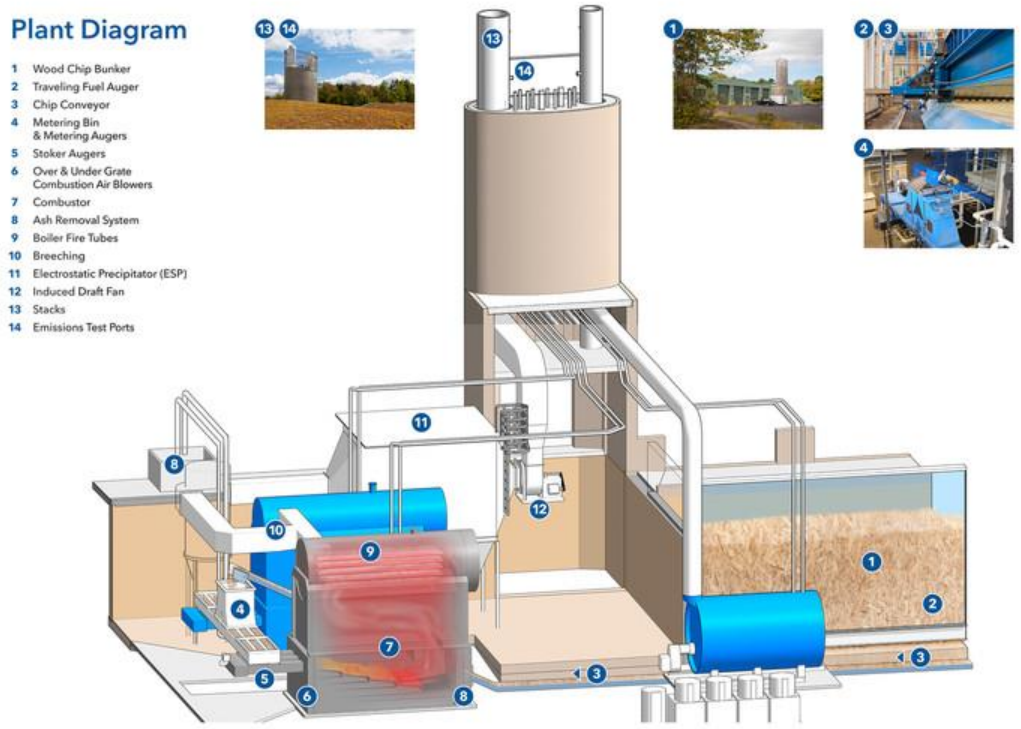
Biomass

Biomass such as raw wood chips and pellets are converted to energy by a variety of means. One of the most common is thermal conversion, where biomass is compressed into briquettes, and burned to produce steam, which in then powers turbines to produce electricity. Another method, pyrolysis, involves heating biomass to 200-300 degrees Celsius (390-570 Fahrenheit) to produce a dark liquid known as pyrolysis oil that can be combusted to generate energy, and in the future, may also replace petroleum.



Source: https://www.archdaily.com/933023/what-is-biomass-energy

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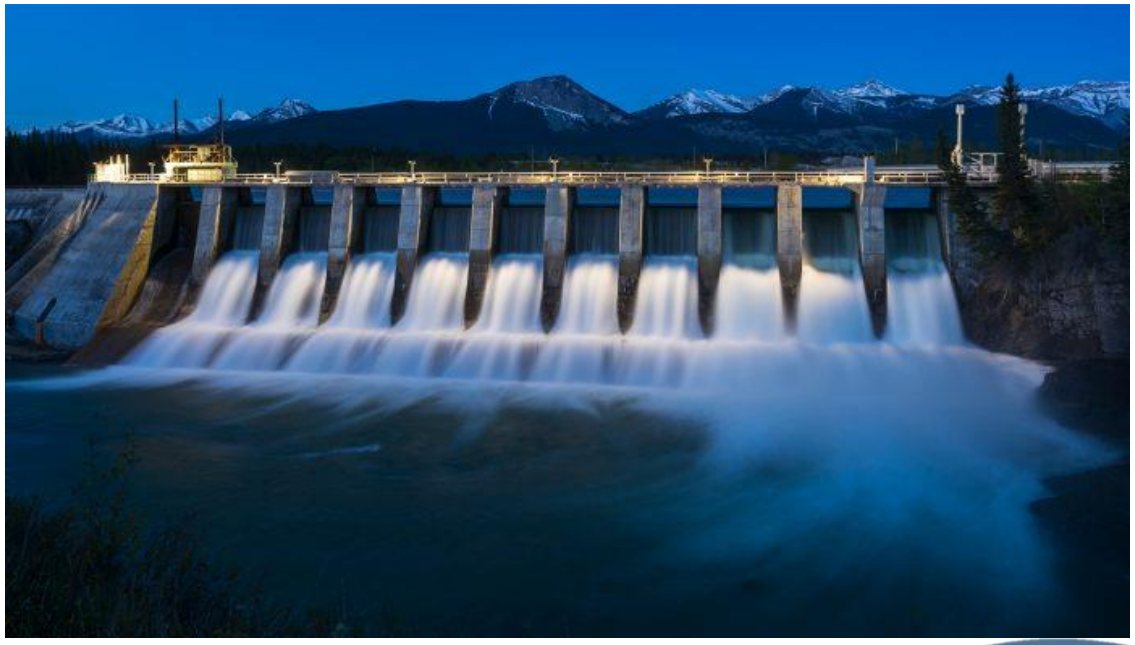
What is Hydroelectric Energy

Hydroelectric power, also called hydropower, electricity produced from generators driven by turbines that convert the potential energy of falling or fast-flowing water into mechanical energy. In the early 21st century, hydroelectric power was the most widely utilized form of renewable energy.



Source:https://www.innovationnewsnetwork.com/hydropower-vs-wind-energy-securing-the-worlds-electricity-supply/6440/

Source: https://www.britannica.com/science/hydroelectric-power

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Application for Multi-functional Green Roofs Facades and Interior Elements

Presentation

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Application for Multi-functional Green Roofs Facades and Interior Elements

From the five examples of energy in construction given above what examples and benefits can these bring to Multi-functional Green Roofs Facades and Interior Elements.

- Solar thermal energy
- Geothermal energy
- Wind energy
- Biomass
- Hydropower

Source: https://architizer.com/blog/inspiration/collections/roof-scapes/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

Main Opportunity

There is a perception that a roof can either have a green roof or solar power but not both. This is however not the case. Combining the two technologies is common in many countries in the world.

Switzerland, Germany and Austria lead the way in the approach.

Source: https://livingroofs.org/green-roofs-solar-power/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

Main Opportunity

There is substantial evidence from Germany and Switzerland that combining solar panels and vegetation can produce the following benefits:

- Solar/Photovoltaic panels can work more efficiently on a roof when installed over a green roof system. The micro-climate around the panels is important. If it is too hot, the panels can lose efficiency. The green roof element can have a cooling effect, especially in summer. Year round, green roofs can help to keep ambient temperatures around the panels at or near 250C. This is the best temperature for solar panels to work most efficiently.

Source: https://livingroofs.org/green-roofs-solar-power/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

Main Opportunity

- A green roof makes the installation of A-frame panels easier. The green roof element provides the ballast to hold the A-frames and panels in place. This means there is no impact on the waterproofing layer below.

Source: https://www.zinco.ca/articles/green-roofs-and-solar-the-ultimate-combination

Source: https://livingroofs.org/green-roofs-solar-power/

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Main Opportunity

- The PV panels should also increase the diversity of vegetation and therefore also fauna using the green roof. The panels can create shaded areas underneath, with rain run-off making damper areas to the front and drier areas behind. This creates a ‘habitat mosaic’, allowing a wider variety of vegetation to flourish, in turn attracting a wider range of butterflies, bees, beetles and other species.

Source: https://urbanstrong.com/blog/integrated-solar-green-roofs-are-for-the-greedy

Source: https://livingroofs.org/green-roofs-solar-power/

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QUIZ/ASSIGNMENT/ACTIVITY

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EXTRA READING/STUDY

Activity

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EXTRA READING/STUDY

For Further Case Studies and Training Material Please Follow the Link Below

https://docs.google.com/spreadsheets/d/1DTte4Ph8pQ4lKzYGFt2_S-d1Z_Rmd9-i/edit?usp=sharing&ouid=112148808974461842163&rtpof=true&sd=true

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EXTRA READING/STUDY

Energy Efficiency for Construction

https://www.shipleyenergy.com/resources/commercial/energy-efficiency-for-construction/

Occupant behaviour lifestyles and effects on building energy use: Investigation on high and low performing building features

https://www.sciencedirect.com/science/article/pii/S1876610217355376

What is energy efficiency in construction and how is it achieved?

https://blog.synthesia.com/en/what-is-energy-efficiency-in-construction-and-how-is-it-achieved

Exploring Energy-Based Sustainable Construction Techniques

https://www.chas.co.uk/blog/sustainable-construction-techniques/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

EXTRA READING/STUDY

Resource efficiency in the building sector

https://ec.europa.eu/environment/eussd/pdf/Resource%20efficiency%20in%20the%20building%20sector.pdf

Indoor Air Quality, Thermal Comfort and Daylight

https://www.bpie.eu/wp-content/uploads/2015/10/BPIE__IndoorAirQuality2015.pdf

Energy efficiency in buildings

https://commission.europa.eu/news/focus-energy-efficiency-buildings-2020-02-17_en

The Innovative Use of Renewable Energy in the Construction Industry

https://www.greenandprosperous.com/blog/the-innovative-use-of-renewable-energy-in-the-construction-industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

EXTRA READING/STUDY

Top 4 Sources of Renewable Energy for Powering Construction

https://theconstructor.org/construction/renewable-energy-sources-powering-construction-sites/561510/

BIMzeED

https://bimzeed.eu/

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https://busgocircular.eu/

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https://www.youtube.com/channel/UCXu4Rjs5WDXBE-yqda5kt5A

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Colophon

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Partners

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